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Detection and estimation of the Slichter mode based on strain observation of the 2010 Chilean earthquake

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The Slichter mode ($_1S_1$) is the longest-period mode of the free oscillations of the Earth. The period of the Slichter mode directly depends on density jump between the outer liquid and the inner solid core which makes the detection of this oscillation very important for gaining a more detailed insight into the structure of the Earth's interior. Reliable empirical data on the detection of Slichter mode are absent, which is associated with the rather low amplitude of this mode on the surface.

In this work, for the first time, an attempt is made to detect the Slichter mode using the strain data from the largest 2010 Chilean earthquake recorded by the Baksan laser interferometer–strainmeter (Sternberg Astronomical Institute of the Moscow State University (SAI MSU)) with a measuring arm length of 75 m in the Elbrus region, the Northern Caucasus.

A new asymptotically optimal algorithm for data analysis is developed. The algorithm uses the maximum likelihood method and takes into account the features of the detected signal and the properties of seismic noise. The algorithm is based on the fundamental principles of the theory of optimal signal reception against the background of non-Gaussian noise, which provides the most effective signal detection in accordance with the Neumann-Pearson optimality criterion. Simultaneously with the detection, the degenerate frequency of the mode and splitting parameter b are estimated. Applying the developed algorithm to the strain data of the Chilean earthquake yielded two sets of the most probable candidates for the Slichter mode parameters: T_1 = 5.905 h at b_1= 0.1038 and T_2 = 6.581 h at b_2= 0.1046. The obtained sets of the Slichter mode parameters have a false-alarm probability of 0.012 and 0.005, respectively.

The comparison of our results with the theoretical models and the previous results of experimental determinations of the period of the Slichter mode shows a close correspondence of the period T_1 = 5.905 h to the period in the CORE11 model (Widmer et al., 1988); the difference is below 1.5%. In the case of the PREM models (Rosat et al., 2006), the obtained periods correspond to the density jumps between the inner and outer cores of $\Delta\rho_1$ = 0.456 g/cm^3 for T_1= 5.905 h and $\Delta\rho_2$ = 0.360 g/cm^3 for T_2 = 6.581 h.

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